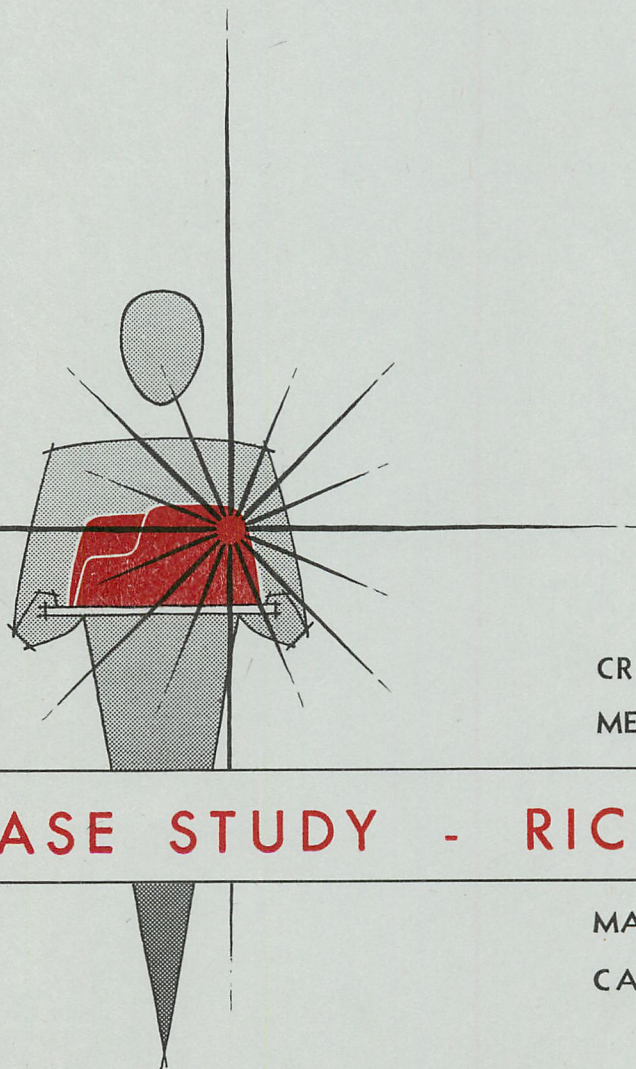




CREATIVE ENGINEERING LABORATORY
MECHANICAL ENGINEERING DEPARTMENT

CASE STUDY - RICE IN BURMA

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, MASSACHUSETTS

CASE STUDY ON RICE IN BURMA

Prepared by:

Andrew T. Ling
Research Assistant
Creative Engineering Laboratory



RICE IN BURMA

INTRODUCTION

For many centuries rice has been an extremely important world food. It is socially and economically significant in a large portion of the world. The annual world production exceeds seven billion bushels, which is equalled only by the production of wheat. While it enters into the diets of most people, rice is the main energy food for some eight hundred and fifty million people of the Oriental nations. Over ninety percent of the world production is concentrated in the monsoon region of the Far East. These regions as a whole are relatively densely populated, and the rice production provides their principal occupation. The standard of living is low and the population tends to multiply rapidly. In certain areas space limitations brought about a practice, centuries old, of striving for the largest and best crop possible year after year for the subsistence of the local people. Yet, the difficulty in maintaining the per capita rice consumption for the rapidly growing population has caused world wide concern since the end of the second World War.

Burma is one of the few rice exporting countries in the region. Rice production constitutes thirty-eight percent of the total annual national income, while two-thirds of the labor population engages in this occupation. However, as in other areas, rice culture in Burma is still carried out under primitive farming methods little changed from the time of antiquity. These methods are characterized by the use of animal power, hand labor, and primitive tools. The present average yield is only twenty-five bushels per acre for a single crop as compared to the almost three times that yield using modern techniques and machinery. There is need for technological improvement in rice culture in Burma, and intensive use of fertilizer must be vigorously advertised. Rice, being one of the important exports, will greatly improve the national economy with an improved yield.

Burma is unique in the fact that the population is low in relation to her potentially cultivable land. Large numbers of laborers are imported from the neighboring countries each year at the time of transplanting and harvesting. Although the best rice-land in Burma has no doubt

already been planted, observations suggest that rice production could be considerably increased through use of presently undeveloped lands. A greater degree of mechanization needs no further emphasis.

Unsuccessful attempts to use modern farm machinery in Burma has strengthened the belief of many agriculturists that mechanical equipment is not suitable for this area. But it should be remembered that the general level of labor skill is very low; modern machinery, under conditions quite different from those for which they were designed for, cannot be expected to function efficiently with untrained hands. Furthermore, Burmese methods have been followed for centuries and there is a natural resistance to changes that depart from their traditional custom. Thus, introduction of modern machinery must be gradual, and the improvement of farming methods and tools must be done without instituting radical changes. It is the responsibility of research to investigate and design or modify farm equipment by studying existing methods and farming conditions.

The geography of Burma is distinctly divided into regions. The mountain system consists of north-south offshoots of the Tibetan mountains; on the west are the Arakan Yomas (hills), the Chin Hills, and the Plateau of the Shan states and the Karenni, averaging 3000 feet above the sea level; on the south-east the Tenasserim Yomas; and in the heart of Burma some 1500 to 3000 feet high are Pegu Yomas. Burma plains comprise a series of river valleys the Irrawaddy, the Sittang, and the Salween running from north to south. It is on the delta of the Irrawaddy that almost all the exporting rice production concentrates. (See Fig. 1)

The coastal regions of Arakan and Tenasserim and the mountains of the extreme north have an annual rainfall of about 200 inches. The delta of the Irrawaddy has 100 inches. The western hills and the eastern hills, 80 inches, while the central Burma average only 25 to 45 inches of rain in one year. The advantage of this part of monsoon Asia is the fact that almost 90% of the total annual rain fall concentrate in the summer months, from April to November, when the need of water for rice growing is most demanding. During the winter months rain fall is rather scarce.

TIBET

CHINA

INDIA

INDOCHINA

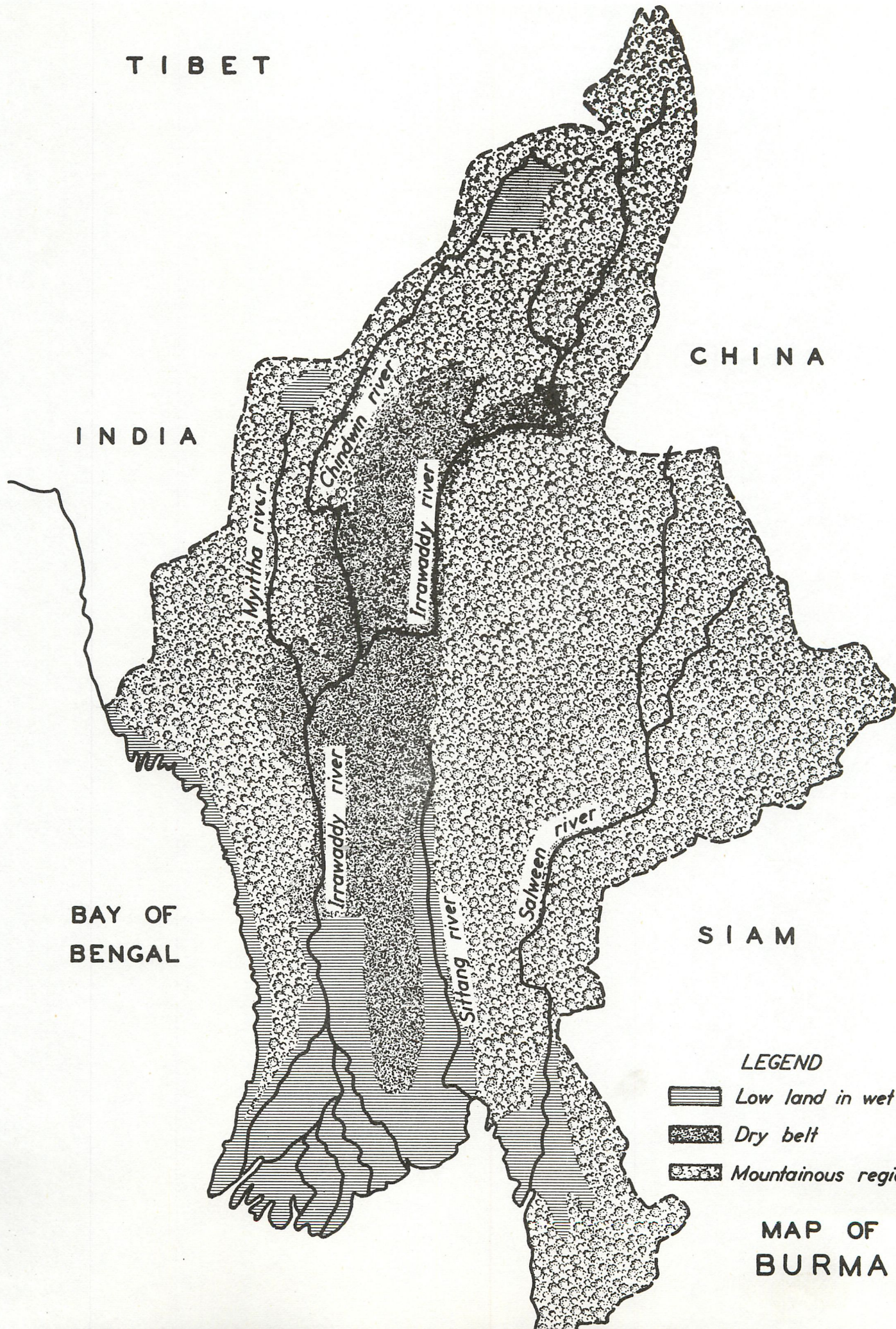
BAY OF
BENGAL

SIAM

LEGEND

-  Low land in wet zone
-  Dry belt
-  Mountainous region

MAP OF
BURMA



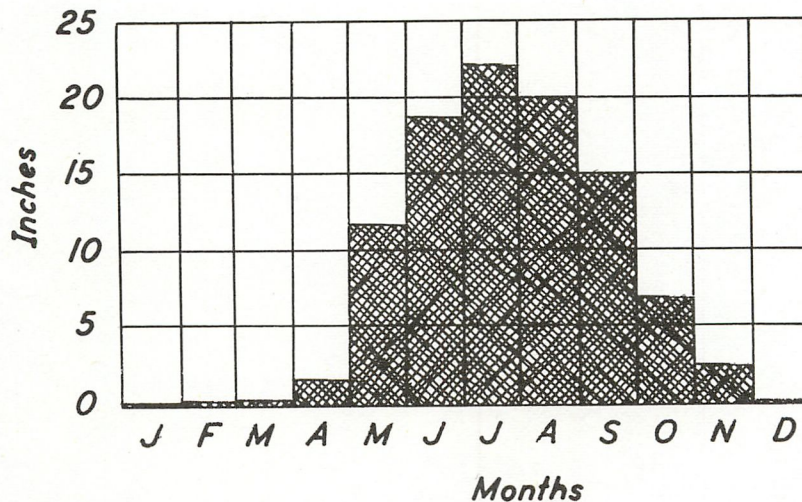


Fig. 2 Average Rainfall for Monsoon Burma

Burma lies well within the tropical zone; temperature is rather high. Average temperature is above the 70's while the lowest winter temperature is seldom below 50. The whole country experiences an annual cycle of dry and humid weather. The Irrawaddy delta and the coastal lands, however, are extremely humid all year around.

The water requirement of the rice crop depends on a number of factors. The principal factors are field evaporation, seepage, preparation of the land, and initial flooding; while the conditions that have important effect on these factors are climatic conditions, characteristics of the soil, length of irrigation period, ground water table, yield and method of planting, as well as methods of irrigation. It is believed that the total amount of water required by the crop is six-feet-acre. In the vast area of Lower Burma, real swamp conditions exist and there appears to be little or no control of the water supply. However, in some areas diking is used as protection from floods and canals are used for drainage. Further up-country irrigation is practiced. Small areas also exist bordering rivers and subject to flood where successive plantings are possible, level by level, as the flood water subsides. In Upper Burma, extension of paddy cultivation has been due mainly to irrigation work carried out by the government.

The total population in 1941 was 16,823,798 of which 9,600,00 were Burmese. To develop this sparsely populated area the government encouraged immigration from Upper Burma and from India by giving leasehold rights on land after continuous payment of land revenue for a period of twelve years. In recent years immigration laws have been tightened, however, and except for the border regions, influx of Indian labor has slowed down considerably; city labor during the growing season moves in to supplement the lack. The labor movement is very fluent, moving from the city to the country and back again as the need fluctuates.

Life of a farmer is an uncomfortable one during the working season as work begins at dawn and continues through dusk. Of course there are occasional rest periods. Meals are delivered by the family to the fields which are usually miles from their homes. Implements, if any, are crude, and physical exertion is apparent in practically all phases of the work. Simple improvements to the farmer's tools would greatly lighten his load and would improve his state of living.

The economic conditions of the farmers are poor. The fertility of the soil and thus the yield and the quality of the produce are steadily declining in recent years. Such is the result of unsatisfactory conditions of cultivation. The two major factors responsible for this continued unsatisfactory condition are: 1. the conditions under which the cultivator holds the land, and 2. his financial instability. Forty-four percent of the paddy land is owned by absentee land-owners who lease annually to cultivators on percentage basis, and of the 56% who are land-owners few have areas of 100 acres or more. Thus, the landlords are at liberty to change tenants each year. The Indian immigrants, their standard of living being lower, work for less than the Burmese and as they move in they often squeeze the latter out of their tenancies. One of the direct results is that none of the tenants try to improve their land, but rather exhausts the soil by getting as much out of it as he can year after year. After the second World War the government advocated a land reform but the immediate situation is not much improved due to political chaos.

In many cases the conditions under which the land is held by the cultivator are directly connected with the financing of the cultivation

of the crop, but the landlord is not alone in taking advantage of the financial instability of the cultivator. The cultivator has to find money for current expenses, implements, seeds; and for advances, shelter and food for his laborers who possess nothing until the paddy is harvested. For all these expenses he looks to his landlord who borrows from the Chettiars or money-lenders; but if the cultivator is also the owner, he looks directly to the Chettiars. The interest rate can be from 1-1/4% to 2-1/2% per month. It is easy to imagine how wide the interest in the crop at harvest time is; everyone is looking for the return of money lent, either in cash or in paddy. The cultivator, too, usually pays his laborers for work during the season in an agreed quantity of paddy. Usually the price of paddy is the lowest at this time resulting from the exploitation of the market controllers who also take in the advantage.

The poverty of the paddy planter is not always caused by the uneconomic conditions of cultivation or marketing, although they may contribute to his position; his poverty is caused by his own improvidence. Given the capital, given the loan to tide him over until harvest, in many cases the money will be diverted from the purpose for which it was borrowed. No attempt is made to plant any kind of winter crop so as to extract more from the soil. It might be the easy-going nature of characteristic tropical people. Grist goes so far as to say: so long as the grower's attitude is as at present, any resulting improvement will only add to the prosperity of the money lender and the landlords. The solution of indebtedness still depends on the personal efforts of the cultivators themselves--the will to become independent.

Government intervention is inevitable. Most of the exports now go through government agents. Since rice exports amount to a sizeable portion of the annual revenue, the government must take the initiative in advocating different kinds of improvements.

RICE

The rice plants are usually called "paddies" or "paddy rice" until the kernals are hulled from the grains. From then on, the product is called "rice". At the intermediate stages, terminology differs from one place to another. For uniformity, the following chart will be used:

Table of Terminology

Paddy	Seed (sown)
	Seedlings (transplanted)
	Plants (harvested)
	Grains (threshed)
Rice	Brown-rice (hulled)
	Skinned-rice (milled)
	Polished-rice (polished or/and dressed)

The culm of the plant grows to a height of three or four feet and is topped by spikelets bearing grains. The spikelets together form a loose panicle on each culm. The kernel of each grain is covered by a golden yellow coat of hard and slightly hairy hull. (See frontispiece)

There are many varieties of grains. In the interest of this study, they may be classified into two general types according to the way they are cultivated. The Upland-rice is cultivated by comparatively primitive methods with no flooding or artificial irrigation due to the difficulties of the environment and lack of rain in the regions in which they are grown. They are found usually in sparsely populated and poorly developed regions where land is abundant, or among the lowland fields as a first crop. Although the yield is poor and the quality low, this crop, accounting for but a small portion of the total world production, is important in certain regions in monsoon Asia where supply from the Lowland fields is not adequate. The Lowland-rice is cultivated under flooded conditions; thus, they are found on stretches of reasonably level land. This is the principal culture of rice that produces more than ninety percent of the total world production. It will be the subject of the following study.

Rice culture is unique in that it requires rather unusual conditions. High average temperatures are needed for cultivation of rice. The minimum temperature at which the seed can germinate is around 50° F. The average temperature for the growing period should be around 68° F. Such a temperature requirement more or less confines rice culture to the semi-tropical and the tropical zones. Although humid weather is not necessary, the demand for water is rather heavy. The average need is estimated at fifteen to thirty-five inches of rain per month during its growth under various conditions of seepage and evaporation. Where rain is not adequate, artificial irrigation is necessary. Rice is not grown in regions where the annual rain fall is less than forty inches. Rice apparently has no special preference for any type of soil although it has an enormous appetite for nutrition; but the circumstances of Lowland-rice cultivation favor the concentration of production on soils of the heavy clay type which has over forty percent of clay in the soil.

Each planting field is subdivided into small plots which are also called "paddies". A paddy must invariably have a layer of heavy subsoil or a hardpan, which helps in holding water and minimizing seepage or percolation. On top of the hardpan is the layer of richly fertilized top-soil also of heavy clay type. The layer is from four to six inches thick on which the plants grow. To keep an even distribution of water, the maximum difference in elevation from one side of the paddy to the other is less than ten to twelve inches. The paddy is surrounded by bunds. The bunds are from one to two feet high and from one to three feet wide at the base, tapering to the top. They are made of compacted clay, stiff mud, and weeds strong enough to hold water for a long period of time, but barely strong enough to serve as paths among the paddies. Openings are made of convenient places for ingress and egress of water. The level of the top-soil surface is lower than the local ground level; the top of the bunds is approximately the ground level. In flat country, ditches thread between the paddies for the purpose of flooding and draining the fields. In rolling country many adjacent paddies may be flooded and drained by opening and closing small outlets on the bunds.



Fig. 3 Typical Paddy Fields Showing
Terrace Cultivation in Burma.

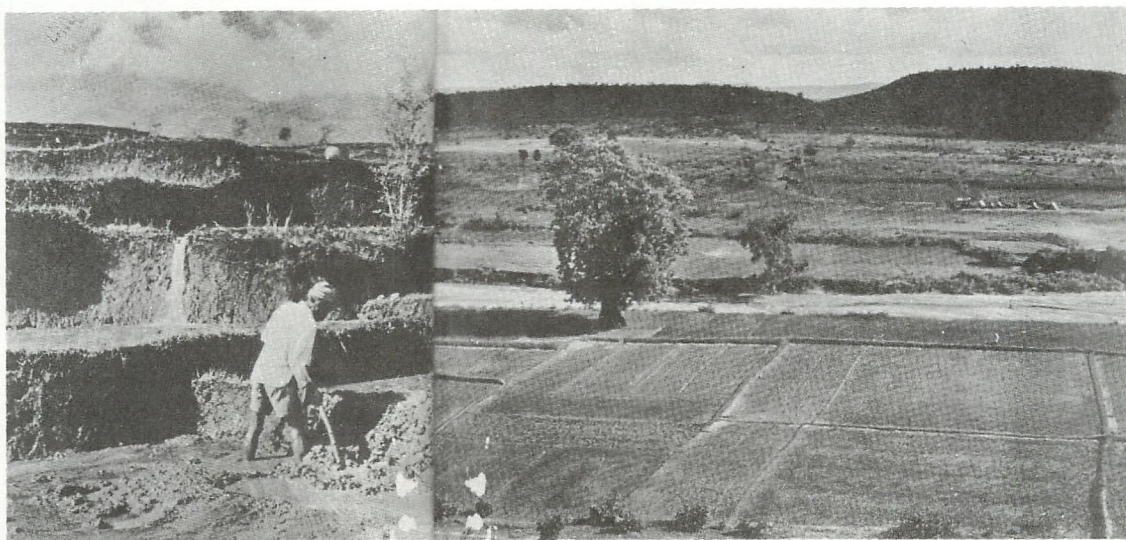


Fig. 4 Terraced Paddy Fields and
Valley Paddy Fields.

Due to the damage from strong winds, even the modern rice paddy may not be more than four to six acres with the stretch away from the prevailing wind. In the Orient, where topography is irregular, the paddies are typically small in size and irregular in shape. On more rugged slopes, they are arranged along different levels frequently giving the effect of broad steps rising from the lower land to the higher. Paddies located in great valleys where the land is level tend to be larger and more uniform in size. Small and irregular paddy sizes are due in part to the fact that each individual holding is small and to the unsystematic method of constructing paddies one after another over a long period of time.

In Burma, the major proportion of the cultivated fields lie in the Irrawaddy Valley and its deltas. A typical individual family holding may amount to six to eight acres and the size of a paddy may vary from one-fifth of an acre (approximately eight by a hundred feet) to not much more than one acre*. There are three sets of conditions under which a rice crop is raised: (1) low-lying swamp land where rainfall is sufficient throughout the growing period to keep the plant in its necessary state of submergence; (2) land less low-lying or with less rainfall but having supplementary water available from natural drainage and seepage or from irrigation schemes; and (3) land bordering tanks or rivers and subject to flood on which successive plantings can be made, level by level, as the flood water subsides.

Rice cultivation may be divided into five phases: soil preparation, nursery sowing, transplanting, irrigating, and harvesting.

* Burma, being a newer rice region like Thailand and Indo-China, has larger average size farms. In most of the other countries in the Orient, the average individual farm holding is only two to four acres.

SOIL PREPARATION

After the previous crop of rice has been harvested, the long stubbles in the field are burned to ashes. Repairs on the fields are made. In some places, a crop for green manure, such as clover, is grown on ridges. With the advent of the monsoon the paddy field preparation begins. The field is flooded by rain or with additional aid of an irrigating pump to a depth of one to five inches. Plowing begins with the breaking up of the ground to a depth of from two to four inches by running a plow once over the ground. (See Fig. 5) Deep plowing is usually unnecessary. The green crop is thus turned over to ferment. At this stage, fertilizer or compost may be applied to the field, although this is seldom done in Burma. The field is then worked over from six to ten times with a harrow. In this way, the soil is gradually pulverized, smoothed, and worked to a layer of mud of a consistency of mortar. One reason for the repetitive harrowing is to break



Fig. 5 Plowing With Wooden Plow.

up the soil structure, thereby decreasing its permeability. The result is less leaching or percolation and consequently reduction in the amount of water wasted. This thorough puddling of the soil also permits the plants to be quickly set and provides conditions which insure immediate perfect contact for the roots.

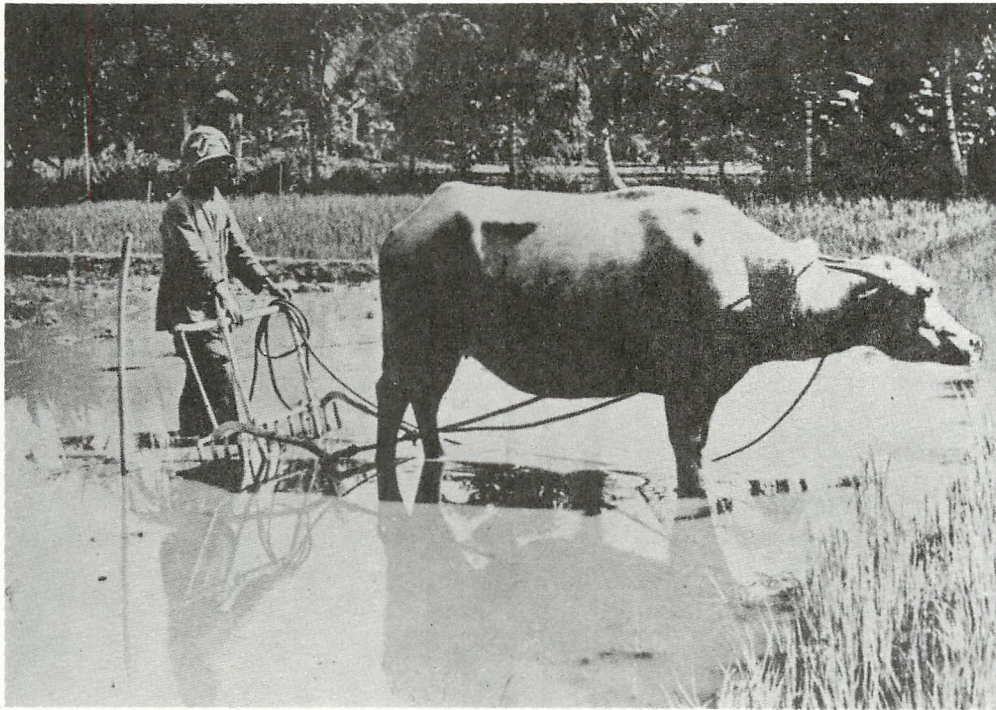


Fig. 6 Soil Preparation with Pointed Harrow.



Fig. 7 Soil Preparation with Rolling Wooden Harrow.

The preparation usually begins late in March when the first rain has softened the soil enough for working and is finished in June when seedlings in the nursery beds are ready for transplanting.

NURSERY SOWING

The nursery beds are a part of the paddy fields that amount to about one tenth of the total planting area. The preparation of these fields is exactly as described before, only with more care and addition of fertilizer. Usually, ten harrowings are done to give a layer of pure smooth mud with all the weeds either collected or buried under. Water is then drained off, leaving a soft mud surface for sowing.

Seeds are soaked in water for twenty-four hours and are left to sprout for another day or two in a basket. The sprouted seeds are then broadcast by hand at a rate of approximately sixty to eighty pounds of dry seeds per acre. After three or four days when the seedlings have taken root, one inch of water is let in. The water level is gradually increased in pace with the growth of the seedlings. After four to six weeks, the seedlings have attained a height of ten to fourteen inches tall and are ready for transplanting. One nursery bed will produce enough seedlings for ten times its area.

This period spans from the middle of May to the end of June. The advantages of transplanting include an important saving of time, more efficient distribution of work, and economy in water and fertilizer. Most of the rice cultivators in monsoon Asia, including Burma, use the transplanting method.

TRANSPLANTING

The paddy fields must be ready simultaneously with the seedlings; the fields are ready when they have a four or five inch layer of fine mud with approximately three inches of water on the surface. The seedlings in the nurseries are carefully up-rooted with the soil rinsed from the roots and tied into bundles that are taken to the paddy fields. The top few inches of leaves

are usually cut off to reduce evaporation and to give rigidity to the plants so that when transplanted the leaves do not bend over into the water. Seedlings are placed into the mud in hills of two to four by a single thrust. The plants are set in rows about eight to ten inches apart and four to eight inches between hills in the row, depending on the fertility of the soil. There is no packing of earth about the roots, each hill being set with a single motion. The nursery beds are immediately remade for transplanting. Seedlings, after up-rooted, usually can live for a few days in the field before being transplanted.

Transplanting is finished by the end of July when the monsoon is at its height. The seedlings at this time are just beginning to be strong feeders, and the fresh, rich new soil and plenty of water provide for their fast growing.



Fig. 8 Typical Hand Transplanting Methods.

IRRIGATING

After transplanting, the fields must be correctly watered so that the growth of the plants keeps pace with the rise of the water level. Care must be taken to change the water occasionally for aeration. Besides that, there is little to do until harvest time. However, where two crops are grown each year or high yields for successive years are expected, the fields must be hoed and fertilized. The setting of the transplanting is to aid in fertilizing and hoeing. The first thing to do is to spade between the hills. The fields are then gone over manually again to smooth and level the stirred soil. Fertilizer is carefully applied.

HARVESTING

Reaping

Ten days before harvesting time, water is drained off the paddies to hasten the ripening of the grains and discourage lodging. Harvesting is sometimes preceded by laying the crop over in a single direction to prevent haphazard blowing over by the wind and to facilitate cutting. The crop is reaped by removing the panicles together with the top foot or so of the culms. The long stubbles are left in the field to be burned later. The culms with the panicles are tied in bundles to be transported to the threshing floor.

Threshing

A threshing floor of hard level surface is prepared. Bundles of paddy panicles are laid on the floor for drying for a week or longer. When dry, the grains are threshed out of the sheaves by beating, or treading. The culms are taken away and the grains are gathered up for winnowing.

Winnowing

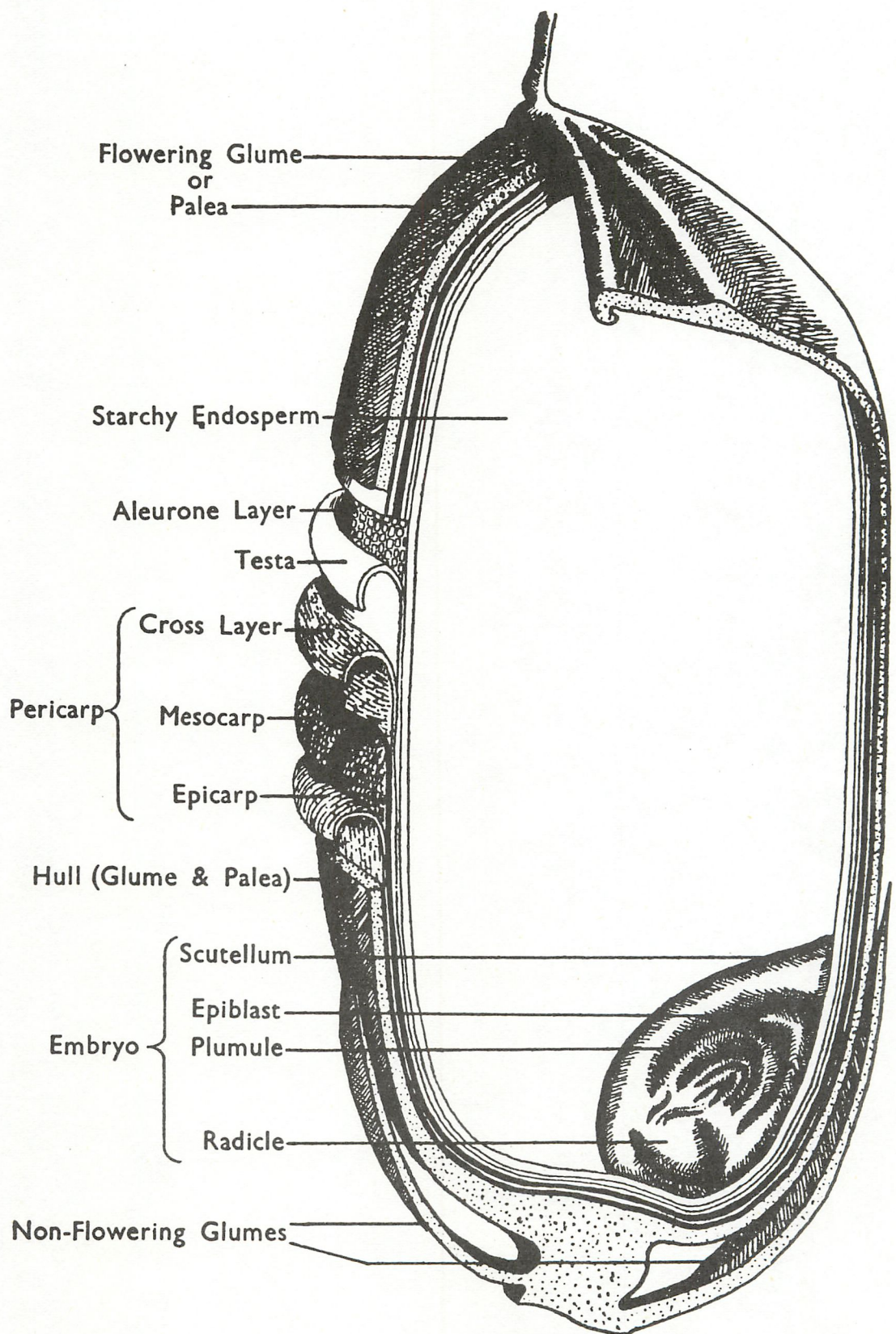
The grains from the threshing floor are mixed with chaffs, dirt, and stones. The winnowing process is to separate the impurities from the paddies as much as possible. The grains are now ready for milling or shipment to milling industry.



Fig. 9 Harvesting with Hand Sickle.



Fig. 10 Typical Threshing Methods.



Structure of the rice grain

The rice cultivation schedule for a single crop in Burma and her adjacent districts may be outlined as follows:

Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Soil Preparation				Growing Season				Harvesting			
Fields burned and fixed	Plowing soil	Nursery sown	Transplanting	Irrigating					Reaping	Threshing	Winnowing

FARM IMPLEMENTS FOR RICE CULTIVATION IN BURMA

Farm implements used in rice cultivation in Burma are simple and crude. Because of the characteristics of the paddies, no modern tractors have ever been successfully employed in these regions. Transportation among the fields is mostly carried out by wooden-wheel animal-drawn carts or animal backs.

SOIL PREPARATION

Plowing is principally done with the Eastern type of wooden plow. The plow is single-furrowed and the point of the sole is generally protected by a piece of iron or simple share. Its purpose is to break up the soil

rather than to cut or turn over a furrow after the manner of the modern steel plows used in the Western countries. Since the plows are drawn by buffaloes or bullocks, they are light and of easy draught. Improved iron plows which have a much higher soil inverting capacity are growing in popularity.

Harrowing is done with either pulverizing harrows or rotary harrows. The pulverizing harrow is a five or six-foot wooden beam onto which from three to eight wooden or iron teeth are inserted. It has an attachment to enable it to be drawn by cattle. The rotary harrow is a similar, more densely toothed beam attached to two end boards so that it can rotate as the harrow moves along. The end boards are tied together by two wooden beams parallel to the rotating beam. The harrow is to puddle and work up the soil to the desired consistency as well as to cut and bury the weeds. Inefficiency of the tools is partially responsible for the numerous repetitions required for each operation.

The recognized rates of working for a pair of cattle per day of six hours are one-third of an acre for plowing and slightly over one acre for harrowing.

TRANSPLANTING

Transplanting in Burma is mostly done by hand. The bundles of seedlings are conveyed to the fields either on sledges or by boat. The process is laborious and back-breaking. The laborer must work in several inches of muddy water and on the ground of a uniformly slippery consistency. He must also endure periodic soaking with the ever-present leech to contend with. The average speed of an experienced laborer is from one sixth to one tenth of an acre per man-day, depending on the denseness of the setting of seedlings.

HARVESTING

Reaping is carried out entirely by hand with only a hand sickle. The modern reaper-binder type machine cannot be economically used due to small sizes of the paddies.

After the paddy panicles are transported to the threshing floor and dried, the threshing process may be done by treading or beating. Treading is the commonest practice in Burma while beating is occasionally done. Both are very primitive methods. In treading, the culms are laid in layers two or three deep around a stake driven into the floor, with the heads pointing towards the stake. Buffaloes or kines, that were used earlier in the soil preparation, are driven slowly around the stake so that in the process the grains become separated from the spikelets. The culms are then cleared away and the grains are swept up to be winnowed. The other method is to beat the panicles against a block of wood or a stone until the grains fall out of the spikelets. Another method is practiced mostly in Japan; in which the panicles are drawn through a metallic comb mounted on wooden legs.

The winnowing tools include a sieve made of narrow strips of bamboo, having a mesh sufficiently large to allow grains to pass through, supported by a tripod five feet high, and a large double-folded manually operated fan. As the grain mixture pours through the sieve, large impurities are separated by the sieve and the chaffs and dirt are blown off by the wind or by artificial fanning.

MODERN RICE CULTURE

In most of the Western countries modern rice culture invariably uses large scale mechanized methods. Rotation of crops is necessary due to the heavy demand on the soil by the large yield of the rice crop; in places where rotation of crops is not practiced the land is used for grazing. In general, rice is cropped once in every three years.

The construction of the paddies is more systematic; each paddy is four to six acres in size. Soil preparation is usually not under flooded conditions since the machine power is great enough to plow dry fields. In certain countries, the bunds around the paddy are built by mechanized methods when the rice crop is to be planted and are levelled off after the crop. The bunds are built wide with a gradual slope so that tractors can go over them. Tractors are used to draw modern steel plows and disc harrows in preparing the soil.

In most Western countries, transplanting is not practiced. Seeds are sown with grain drills; or they are broadcast and followed by harrowing. Modern pumping methods are used to flood the field during the growth of the plants; good drainage enables the fields to dry in a few days before harvesting to be able to support a tractor. Three kinds of machines are used in harvesting: the reaper and binder, headers, and fore-cut headers. They are drawn by tractors of one kind or another.

Where transplanting is practiced, special hand tools have been developed such as those used in Italy. Some progress has also been made with the development of an animal-drawn transplanting machine.

The yield by the modern methods in certain regions has been over one hundred bushels of paddy rice per acre and certainly an average yield of over seventy bushels per acre can be expected.

MECHANIZATION OF RICE CULTIVATION IN BURMA

Before one sets out to consider this problem, it must be noted that mechanization does not necessarily mean completely new tool design or methods, but in many cases improvement of the existing implements or modifications of some of the modern equipment to cope with the conditions.

There are many conditions of rice culture in Burma that challenge our original thinking. There is room for more efficient implements and/or methods in soil preparation. Improvement in the means of transportation on the farms has been unduly neglected. The strenuous transplanting process welcomes partial mechanization. Better methods and implements may be sought for the various phases of the harvesting operations, such as reaping and grain threshing.

Burma has been a major exporter of rice for many years and is financially able to support improved practices for increasing her agriculture output. But the farmers still are small holders of land and for the time being, economic gain in relation to the original cost and upkeep of new machinery is an important consideration. Due to the limitation of fuel, the choice of power is curtailed and some believe that efforts should be mainly directed to the improvement of animal-drawn or hand-operated implements. Since in

most cases farm holdings are small, and in most cases are situated on rolling slopes where cascaded paddies are necessary, maneuverability and lightness of weight are important. Also, the general level of literacy and skill of the labor is low; simplicity and ease in use are necessary.

RICE MILLING

Paddy rice from the threshing floor is a grain covered by a hard, tight-fitting hull. Inside the hull is the kernel which consists of, in greater part, the white endosperm core and a tight adherent straw-colored layer of bran. A small embryo or germ lies at one end of the endosperm.

The paddy rice is first hulled out of the hard hull. The bran has seven sublayers and is coarse tasting. Although most of the vitamins lie in the bran layer, it is removed by milling and polishing. Rice is eaten with different degrees of the bran layer removed. The removed bran and the meals and the lower grades of broken rice are used for feeds. The husks are used economically as fuel. The finished rice is, in general, sixty-six percent of the paddy by volume for normal grade paddy and only fifty percent for low grade paddy.

The size and quality of the skinned and polished rice determine partially the price value. Rice is also graded by the amount of broken rice present, although there is no difference in nutritious value between the whole-grain and the brokens. In Burma, there are many commercial grades of whole-grain rice, fewer of broken rice, parboil rice, and by-products such as bran and meal. The more significant ones are tabulated below to show the percentages of broken rice involved.

TABLE OF COMMON GRADES OF RICE IN BURMA

Europe	No. 1	Highest grade; 15% brokens of high grade
	No. 2	15% to 30% of brokens of different grades
	No. 3	Not more than 30% brokens
Strait Quality		35% to 40% of brokens
Small Mill Special		Up to 42% of brokens; No. 2 grade; Less red grain.
Big Mill Special		42% or more of brokens; lower grade; more red grains allowed

In general, classification of rice in Burma may be divided into five groups and seven types. The groups are defined by the length and the breadth of the grains, based on millers' requirements. The following table gives the dimensions of each of the five groups.

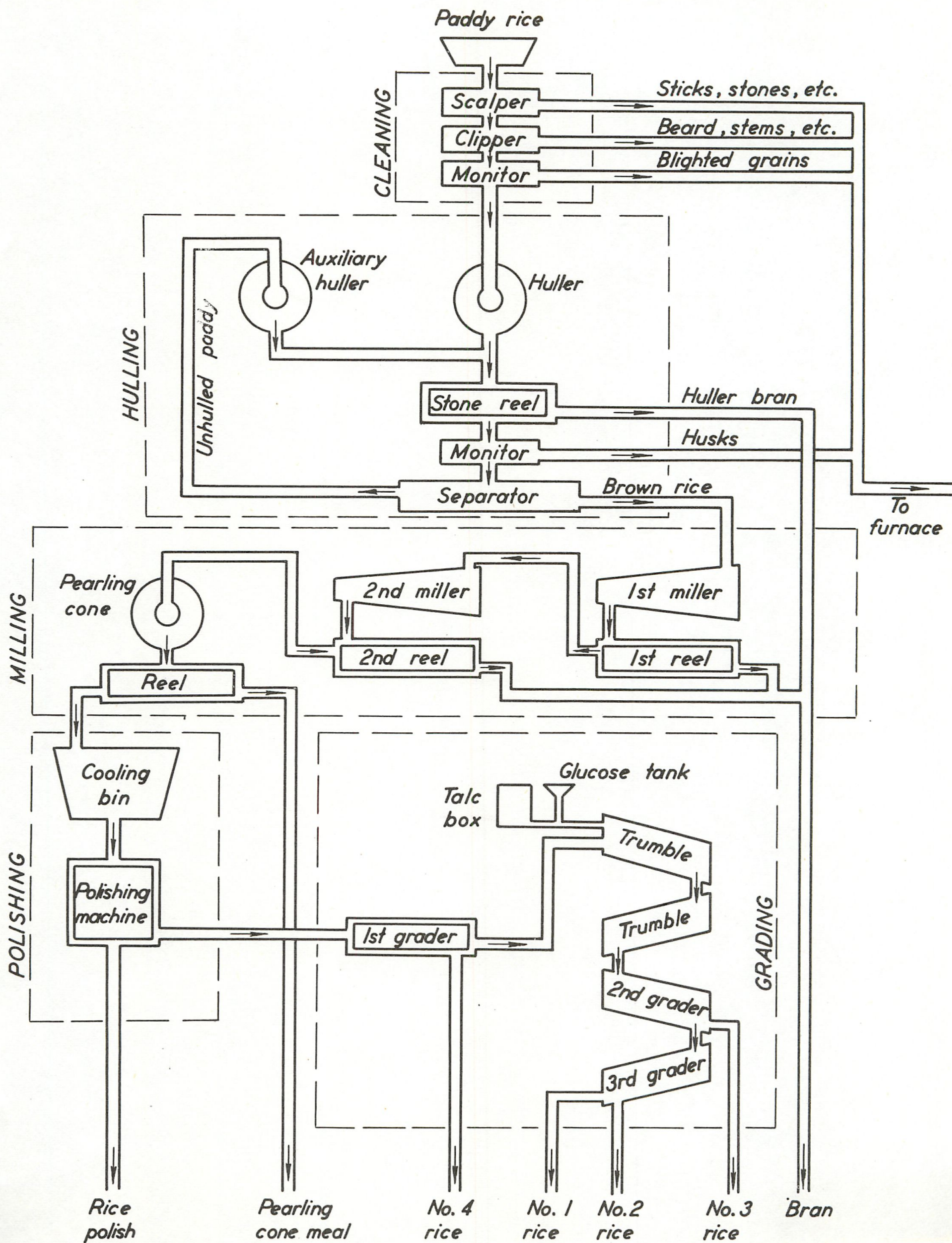
TABLE OF DIMENSIONS OF GRAINS IN BURMA

Group Name	Dimensions of Grains in mm.			
	With Hulls		Hulled	
	Length	Breadth	Length	Breadth
Emata	Over 9.4	Over 3.3	Over 7.0	Over 3.0
Letywezin	8.4-9.8	2.8-3.3	6.0-7.0	2.4-3.0
Ngasein	7.75-9.0	2.4-2.8	5.6-6.4	2.0-2.4
Medon	7.35-8.6	2.0-2.4	5.0-6.0	1.6-2.0
Byat	9.0 up	2.25-3.0	6.4-7.35	2.1-2.5

The earliest and crudest rice milling is done by hand. The implements used are a long-headed hand pestle and a mortar receptacle. Repeated pounding with the pestle breaks the hulls and removes some of the bran through the abrasive action of the grains upon each other. The brans and the husk are then removed by winnowing. This hand method may mill 50 pounds of paddy per hour. Larger "woodpecker" mills are based on the same principle except for the slightly improved tools. The pestle is attached to a six to eight foot long wooden pole which is placed on a fulcrum; the receptacle is larger. The output is much greater. These are the home methods for local consumption in or near the fields.

For exports, the paddy rice is carried by animals or animal-drawn carts to shipping stations for shipment to large milling and packing centers of the region. Present machines are mostly powered by steam; the fuel used is economically supplied by the husks from the paddy during the hulling process.

Rice milling involves five main phases; namely, cleaning, hulling, milling, polishing, and grading. A process progress chart is outlined in the attached diagram.



CLEANING

The paddy from the fields are mixed with straw, dust, small stones, dead grains, and other foreign matter. The paddies are conveyed through oscillating screens or shaking riddles that separate out the larger impurities. In more modern mills, the paddies are shifted successively through three types of equipment: the scalper, which removes larger matters like stones; the clipper, which removes the straws and beards; and the monitor, which removes dead grains. The paddies are then shifted past an aspirator that blows away the lighter matter and the dust. The cleaning machine is generally huge in size.

HULLING

This is a shelling process that separates the grain kernels from the hard outer shells or hulls. The huller consists of a horizontal rotating disc or runner and a stationary disc fixed directly above the runner. The disks are made of stone or cast iron and the adjacent faces are coated with artificial surfaces of stone dressing as emery and cement which are kept flat but rough. The paddies are fed from the top by a hopper through a hole in the center of the stationary disc and are carried outwards between the surfaces by centrifugal action. During this passage the hulls are cracked by the pressure exerted on their ends and the kernels fall out. The mixture is collected on the circumference of the runner.

The gap between the disks can be adjusted and the setting of this gap requires considerable skill. Due to the variation in grain sizes, for each setting there will be broken rice as well as unhulled paddies among the husks and brown rice. This percentage depends on the uniformity of the paddies and the setting of the gap.

The mixture from the huller goes into a separator. The husks and the broken rice are separated by a screening or reeling process and a winnowing process. The mixture of brown rice and unhulled paddies goes into a compartment separator. One of the more commonly used compartment separators is

the "Schule Compartment Separator". It consists of a series of zigzag compartments on a large rectangular tray which is inclined at an angle. The tray shakes back and forth in the direction at right angle to the incline. Shaking and gravity cause the brown rice which are smooth-skinned to fall off the lower edge while the unhulled paddies which are hairy and lighter work their way off the upper edge. The latter is then fed back into a huller with a smaller setting.

MILLING

The milling process is to grind off the outer six bran layers of the brown rice. There are two types of milling or skinning machines. One skinning machine consists of a grooved tapering drum revolving within a concentric hollow cylinder. The drum is so spaced as to rub off the bran with as little breakage as possible. Brown rice is fed from the top and larger end while the mixture of skinned rice, broken rice, and brans comes out from the bottom. Usually the skinned rice is separated from the mixture and fed through successive skinning machines with closer setting so as to remove a desired amount of bran in a more gradual way. The other milling machine is the pearling cone. It is an inverted cone, normally made of iron, whose outer surface is coated with an artificial stone dressing like the huller disks. The cone revolves at a relatively high speed on a vertical spindle within a casing or crib of wire mesh or perforated sheet. The brown rice is fed from the top, passing down through the narrow annular space between the abrasive surface and the casing, during which the brans are rubbed off. The progress of the flow is restricted by rubber or steel brakes fixed to the casing, thus, increasing the milling action. Brans and a limited amount of broken rice fall through the casing perforation, while the main flow comes out of the bottom. Milling is usually done with a roughing cone and then a finishing cone.

POLISHING

Polishing removes the remaining innermost layer of bran and any floury particles adhering to the kernels. The machine is similar to the milling

machine, except that the rubbing action is not so severe. The conical runner is made of wood covered with strips of sheep skin, buffalo hide, or rubber sheet. The rice is polished while brushed between the skin and the casing.

GRADING

Grading is done by a series of sieves and reels equipped with different sizes of perforated sheets which, stage by stage, permit the smaller sizes and grades of broken rice to pass through for bagging. The rice containing the correct proportion of broken rice, passes over a last aspirator through a hopper and into a marked bag, which is then weighed, sewn, checked, and tallied.

SEPARATING

In between each milling or polishing operation, the whole-grain rice is separated from the bran meals and broken rice. This is done by passing the mixture through a separator which consists of sifting screens or reels and aspirating fan wheels. Most of the bran and meals are lost to the air in the machines presently used in Burma.

The rice milling industry in Burma spreads out into five zones due to the scattered sources of the paddies. Smaller interior mills of ten to seventy-five tons of paddies per day tend to replace the larger and older mills on the coastal region and the primitive mills throughout the country. These newer mills have the advantage of being closer to the paddy fields. The existing milling capacity of all the mills is estimated to be in excess of the annual paddy production in the foreseeable future. The principal interest at the present time is in improving the process and modernizing the existing mills, to reduce the milling costs, and to improve the quality of the finished product.

E.C.A. reported in 1951 that the milling of rice in Burma produced a much greater percentage of broken rice than in any other rice milling country. This deterioration results from the fact that not all the mills are in as good a condition as before the war and also from a considerably reduction in the

quality of the paddy. The breakage loss reduces the standard of the finished rice and limits the export market value; the national revenue is affected to a appreciable extent. Fifty percent of the present milling machineries are in such disrepair that they are beyond modernization. Improved design and method or even correct recommendation of modern machinery, as used by the Western countries, will definitely be needed.

Breakage is due mostly to the uneven grain sizes of the collected paddies; a classification equipment of some sort to separate the sizes more carefully may reduce the breakage problem. Consideration might be made on saving of more of the by-products such as brans and meals in each separating process. Some of the modern machines on the market, such as S. Howe's "Eureka" cleaner and chaff separator, Hart-Carter Company or Superior Separator Company's separator, and Engelberg's Huller, may prove informative.

BIBLIOGRAPHY

1. "Burma Pamphlets," Longmans, Green and Co., Ltd. 1941.
2. "Rice," E. B. Copeland, London, 1924.
3. "Rice," D. H. Grist, Longmans, Green and Co., Ltd., London and New York, 1953.
4. "Farmers of Forty Centuries," F. H. King, Mrs. F. H. King, Madison, Wisconsin, 1911.
5. "Comprehensive Report on Economic and Engineering Survey of Burma for Ministry of National Planning," Knappen, Tippetts, Abbett Engineering Company, August, 1953.
6. "Mechanization of the Cultivation and Harvesting of Rice," Trade Relation Research Bureau, Report No. 5, England, May, 1947.
7. "The By-products of Rice Milling," J. B. Reed and F. W. Liepsner, U. S. Department of Agriculture Bulletin No. 570, Washington, D.C. August, 1917.
8. "The Rice Economy of Monsoon Asia," V. D. Wickizer and M. K. Bennett, Food Research Institute, Stanford University Press, 1941.

